MULTIPLE BAND RECEIVERS

LESSON ND-28

SPRAYBERRY ACADEMY of RADIO

ESTABLISHED 1932

PUEBLO, COLORADO

MULTIPLE BAND RECEIVERS

LESSON ND-28

The common name for a multiple band receiver is an all wave receiver. However, this is a misnomer because the receiver has not been built which covers all of the frequency bands now in use. In general, it may be said that a rereiver having more than three tuning bands will fit the broad meaning of the term *all wave receiver*. More technically, such receivers are known as *multiple band* receivers.

The need for such a receiver grew out of the desire of many people to have one receiver which would receive signals in the broadcast, police and the so-called short wave bands. It has not been so long ago since separate receivers were used for all of these functions. Since only the tuning section of such receivers was different, the logical development was one receiver to cover all frequency bands over which signals were to be received. Thus, there have been sold many thousands of receivers with many variations in their circuits to accomplish this requirement. Such receivers are exactly like those you have already studied in your SAR lessons. The only difference is that capacity and inductance values must be smaller to permit tuning to the higher frequencies and some method must be provided to permit switching from one tuning band to another. This has introduced many more complex design problems, many of which have not yet been overcome. Basically, however, the multiple band receiver uses the same basic superheterodyne circuit as used in the single band broadcast receiver.

The rapid and complete development of the broadcast band range of frequencies from 540 to 1600 KC has been largely due to the fact that the technical problems involved were less complex than in any other part of the entire frequency spectrum. One of the first characteristics discovered about the transmission of these frequencies was the relative power required to transmit a given signal a given distance. Consider, as an example, a signal to be transmitted 10 miles with a field strength of 1000 microvolts at the receiver. Curve A in Fig. 1 shows roughly the relative power required to be transmitted for these conditions. The actual power is not important, but the comparison of the power at one frequency to that of another is important. Note that even within the broadcast band less power is required for high frequency transmission than for low frequencies.

Early investigations by Hertz and others were carried out using very short waves, around 2 to 3 meters. At this point you might want to know that there is a definite relation between wavelength in meters and frequency in kilocycles. These are related to the velocity or

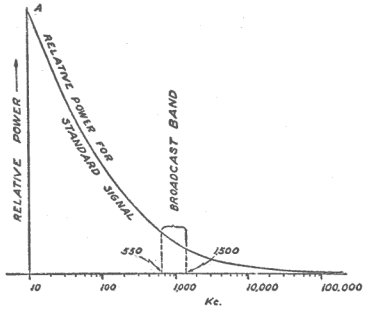


FIG. 1

rate at which radio waves travel. The meter is a European measurement and thus wavelength in meters is often referred to in radio literature instead of frequency in cycles. By measurement and calculation, the velocity of radio waves has been found to be approximately 299,820,000 meters per second. Unless extreme accuracy is required, the value 300,000,000 meters per second is most often used. The formula showing the relation between velocity, wavelength and frequency is in the same form as the familiar ohm's law. It is stated as follows:

$$\text{Velocity} = \text{Wavelength} \times \text{Frequency}$$

$$\text{Wavelength} = \frac{\text{Velocity}}{\text{Frequency}}$$

$$\text{Frequency} = \frac{\text{Velocity}}{\text{Wavelength}}$$

To obtain an answer in kilocycles, $F = \frac{300,000}{\text{Wavelength}}$ Thus a wavelength of 3 meters is equal to $\frac{300,000}{3} = 100,000$ kilocycles or 100 megacycles. To change kilocycles to megacycles multiply by .001. Likewise, a frequency of 150,000 kilocycles is equal to $\frac{300,000}{150,000}$ or 2 meters. If the frequency was given as 150 megacycles, its value in meters would equal $\frac{300}{150}$ or 2 meters as before.

To return to the early investigations of Hertz and others, these were almost completely forgotten for a number of years as the problems required to use wavelengths of 2 or 3 meters have only recently been overcome. Naturally, the frequencies most easily used were developed first and most rapidly. If it were not for the fact that these desirable channels gradually were filled, forcing expansion on both sides of the frequency spectrum, they probably never would have been developed as they are today.

A chart is shown in Fig. 2 showing how completely a *portion* of the radio frequency spectrum is being used at present. Its range extends from 10 KC to 1000 megacycles (MC). In the range of frequencies above 40 megacycles most of the frequency modulation and television signals are transmitted. These may go on up to 500 megacycles or more. As research and techniques improve, practical transmission of radio signals will extend much beyond 1000 megacycles.

Between 300 KC (3 MC) and 30,000 KC (30 MC) there is a large expanse of the radio fre-

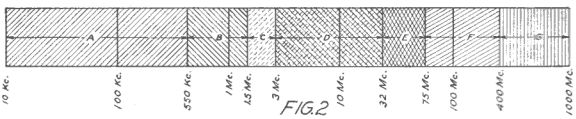


FIG.2

quency spectrum which is very useful and is largely filled up with transmission of some twenty different kinds of service. You should keep in mind, however, that frequency assignments are subject to change and the figures given in this lesson can only be relative. On some frequencies in the 3 to 30 megacycle band, two or three stations may be assigned which share the time of day between themselves. There are, of course, *gaps* in this frequency area which are assigned and which are not being fully used, but they are reserved by international agreement to be distributed to the various nations according to demand.

These frequencies, 3 MC to 30 MC must be controlled by international agreement because interference and station heterodynes at the frequencies becomes a world-wide problem. A signal in Sydney, Australia, may interfere with one in Warsaw, Poland, or in London, while being received in Chicago, or Denver, if they are near the same frequency. While there seems to be an adequate area in this large freqency spectrum, it must be divided for the various countries of the world. This makes the assignment for one nation small.

To better understand frequency assignments, a study of Fig. 2 will be helpful. The first section at the left, marked A, is only useful for high powered commercial services. Up to 105 KC is reserved for government and point-to-point commercial stations, for press, weather information and the transaction of government business. From 105 KC on up to 500 KC is considerably more valuable because *less power* is required and thus much greater efficiency is obtained. This section of the spectrum is used for Coastal Telegraph, Ship Telegraph, Aviation, Government and point-to-point services. It must be recognized that ship communication is world wide in scope, the allocation frequencies being divided for the various nations. Various parts of this section of the frequency spectrum from 100 KC to 530 KC is used in many well separated countries for regular entertainment broadcasting.

Commercial wave bands are not alloted by definite operating frequencies for each station but rather by the allotment of a certain band, such as 5640 to 5695 KC, for example. Any station assigned to this allotment is privileged to operate on any frequency between and including those two mentioned. Thus, you may hear an airport station or plane transmitting on 5672 KC at one time and the same station on 5641 KC at another time. They must shift frequency in many cases to avoid station interference or to avoid weather or location hindrances. No commercial or other type station is permitted to remain on 500 KC as this is the international SOS distress frequency. For the Great Lakes region it is 410 KC. Emergency transmitters are fixed tuned to 500 or 410 KC, but they are only operated in case of distress or extreme emergency. Other communication transmitters may be adjusted to 410 and 500 KC for distress purposes.

Next, in Fig. 2, is section B, which is the U.S. and Canadian

broadcast band. Mexico has a few frequencies in this band and so has Cuba. Otherwise, there are no stations in this band for any other service on the North American Continent. Certain parts of this band are used by other countries remote from North America, but interference is practically impossible.

Section C of Fig. 2 in the radio spectrum from 1.5 to 3 megacycles is given to a great number of services in various classifications as follows: State and Municipal police, Broadcast experimental, Marine, Fire, Geophysical, Aviation, Amateur, Broadcast pickup, Ship harbor, Government, Coastal harbor, Aviation and emergency. This band is often called the *Police Band* because the most consistent reception in this part of the spectrum is from police transmission.

In section D of Fig. 2, extending approximately from 3 to 32 megacycles, interspersed with all those mentioned for band C, plus additional services such as Press, Agricultural, Relay broadcast, Coastal and Ship telegraph, there is world wide short wave broadcasting. This section, as you will note, is quite large. If it were divided into 10 KC channels, as is done for the broadcast band, there would be 2900 channels. Compared to only 106 channels in the broadcast band, this seems to be adequate space for world wide transmission. Stations are not separated precisely in this band as they are in the broadcast band. There are a great number of various types of waves transmitted, and each has its special problems. Unmodulated telegraph transmitter carriers may be placed much closer together in frequency than voice modulated carriers. This is true also of tone modulated carriers and of other continuous wave transmission. Such carreirs are spaced in some cases down to as low as 2, 4 and 6 KC apart, or they may be tuned anywhere within a certain zone of frequencies like amateur transmissions.

These services, except world wide short wave broadcasting, continue into section E of Fig. 2 up to about 40 megacycles. From this point on to about 500 megacycles, where trans-oceanic communication becomes impossible, there is a useful space reserved, in part, for short distance frequency modulation transmission, for television service and experimental transmission. Experimental work in this band, of course, is largely with television and frequency modulation. There is one wide band above F in Fig. 2 lettered G. Generally speaking, these higher frequency bands are experimental. In days gone by, it was the practice to refer to all frequencies above the broadcast band (above 1600 KC) as the high frequencies. As research went on, however, new terms came into use with experimental endeavors reaching up to 30,000 megacycles. So today the terms *high frequency* (hf), *very high frequency* (vhf) and *ultra high frequencies* (uhf) are rather loose terms to designate a broad band of frequencies which are not clearly defined. From 3 to 30 megacycles usually includes the high frequency band, from 30 to 300 megacycles the very high frequency band, from 300 to 3000 megacycles

the ultra-high frequency band and from 3000 to 30,000 megacycles is often called the superhigh frequency (shf) band.

The entire useful frequency spectrum from its lower frequency limit to what may be its upper frequency limit has been outlined in brief. This lesson will cover particularly bands C and D where a great portion of radio interest has centered in the last few years. Receiver design has made history in these bands since 1930 as the majority of present day receivers have one or more bands in this part of the frequency spectrum in addition to the broadcast band. Since the most desirable long distance transmission-reception part of the short wave bands are in sections C and D of Fig. 2, the design of receiving systems for the reception of these frequencies will be considered in this lesson.

CIRCUIT CONSIDERATIONS

In your previous studies you have learned that the frequency of a tuned circuit may be increased almost indefinitely *by decreasing its inductance,* its capacity or by decreasing the value of both. However, a number of other factors, such as the "Q" of a circuit, its losses, etc., are of utmost importance in high frequency reception.

The history of development of multiband tuning systems or all wave receivers is full of trial and error experiments and has led to practically a uniform design practice for present day circuits.

Attempts have been made to vary the inductance by means of a *variometer* which is simply a continuous inductance wound on two concentric spheres or cylinders, one rotating within the other so that the inductance may be varied with coupling. High frequency resistance losses prevented this method from being very successful. The RF tuning inductances have also been varied by means of taps affixed to coils so that only a section of the coil could be used, but the tapped section of the coil would exhibit a greater loss than the entire coil when thus connected. A sliding contact on the windings of a single layer coil met with the same and even greater drawbacks and was discarded. The final and best solution found to date is to use a separate coil for each frequency band but with the same tuning condenser regardless of the number of coils.

It was recognized very early that the reduction of the capacity of a tuned circuit below a certain point was not possible because of the mechanical arrangement of the parts and the distributed capacity of the coil. Thus, if the tuning condenser is completely removed from its tuned circuit, the frequency of the coil alone would hardly increase to more than 50% of the tuning condenser value at minimum capacity. The coil alone with its distributed capacity will, of course, form a resonant circuit at a certain frequency.

These findings led to the separate coil system, which is used in various forms for nearly all present day all wave receivers. The relation of the primary to the secondary is very vital in connection with adapting RF transformers or coils to tubes and circuit arrangements. Thus, when any tuned sec-

ondary is changed, it must have its own primary designed to be used with it for a particular purpose. Because of this an all wave switching arrangement usually includes provisions for the primary as well as for the secondary of the coils for each band.

It is both difficult and misleading to attempt a great deal of general statements concerning dual band and multiband receivers Manufacturers have been more individual here than in any other design feature in all of radio. The facts of the following survey must, therefore, not be taken as literally true because there are broad exceptions to any statement which can be made at this time.

Of the receivers designed for two band operation, there are those covering a band below the broadcast frequencies, and broadcast frequencies principally for export, those having the broadcast frequencies and the next adjacent bands often called the police band, and those having the broadcast band and one high frequency band between 5.5 and 19 megacycles. For example, typical cases are:

Long Wave KC	Broadcast KC	Police MC	Short Wave MC
1.	530-1600		
2. 140-410	540-1740		
3.	540-1500	1.5-4	
4.	550-1720		5.5-16

Other receivers may have as many as five bands as follows:
540-1530 KC; 1.495-4.2 MC; 3.95-11.5 MC; 8-21.75 MC; 20-42 MC; or 150-410 KC; 530-1800 KC; 1.8-6.4 MC; 6.4-23 MC; 23-60 MC.
A receiver may have from one to five bands and these five may be divided in any way that the manufacturer sees fit to divide them. There is no standard practice even with regard to the broadcast band, as there are continuous radio services adjacent to both sides of the broadcast band. Thus, broadcast dials will be marked variously as for example:

535-1730 KC	550-1750 KC
540-1720 KC	525-1700 KC
540-1600 KC	525-1695 KC
540-1500 KC	530-1800 KC
550-1740 KC	540-1860 KC

There are a few general things which can be said about the divisions of the other bands. Since the same tuning condenser is used to tune all other bands, the maximum to minimum capacity ratio of the tuning gang condenser will remain constant. This makes the frequency ratio of the tuned circuit about 3. For some receivers the frequency ratio may go up to about 3.3 or to 3.5—it not being practical to get a much higher ratio than this for one band. Up to about 20 MC the same ratio will hold true because the reduced coil capacity and circuit capacity will ordinarily tend to compensate for the use of a separate trimmer condenser on each short wave tuning coil for individual adjustment. Above 20 MC, the frequency bands are likely to have maximum to minimum frequency ratios of around 2 for reasons which will be brought out later. For example, in the bands for the previously mentioned all wave receiver, the following ratios are obtained:

410/150=2.73	long-wave band
1800/530=3.39	broadcast band
6.4/1.8 =3.55	1st short wave band
23/6.4 =3.59	2nd short wave band
60/23 =2.6	3rd short wave band

Thie shows exceptional coverage due to all frequency ratios being

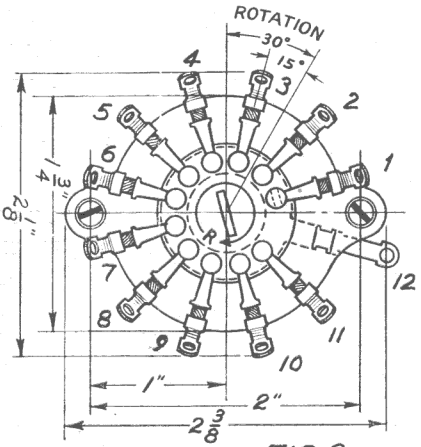


FIG. 3

high. In this way the ratios are always limited at the long waves and at the very short waves. With the exception of the long wave band and the broadcast band, usually the various bands are made to meet exactly or they overlap a few kilocycles for each band to insure complete coverage of the entire frequency spectrum from the lowest to the highest in the tuning range.

MULTIBAND SWITCHING SYSTEMS

The success of the modern all wave receiver of today is based on *ingenious designs* of all wave or multiple deck switches. Before complicated all wave circuits can be traced successfully, you must have a good understanding of the mechanics of all switches. An all wave receiver incorporating several frequency bands must, for simplicity of design and operation, employ a switching system that includes several *moving contacts* as well as several *non-moving contacts.*

Figure 3 shows one deck of a very popular type of multiband switch. In this type of switch the form holding the contacts is made from an impregnated sheet of canvas (very strong with a high insulating factor). Other switches use other forms of insulation. Whatever the type of insulation it must have good mechanical strength and have low *high frequency* losses (leakage). Referring to Fig. 3 again, in the insulation are mounted eleven *non-moving* terminals. A twelfth terminal is used but the switch arm connected to it is movable. The center of the switch consists of a round movable piece of insulating material (R) through which extends a metal shaft. This shaft also extends through the cabinet of the receiver and a control knob is attached to the end of it. Thus the switch may be turned to any one of its eleven positions from the front of the receiver.

While the moving element R of Fig. 3 is an insulating material, it has a metal arm attached to it. Therefore, when R is turned, this metal arm, in turn, makes contact to each of the fixed terminals, one at a time.

The metal arm affixed to R rests at all times on a metal ring mounted beneath it (metal ring not shown in Fig. 3). This metal ring, in turn, is a part of terminal No. 12 of Fig. 3. Thus, no matter what position R is turned to *one of the non-movable terminals* of the switch will at *all times* be connected to terminal No. 12 by means of the metal arm affixed to R. This type of switch is called the *non-shorting* type—meaning a type of switch in which the moveable arm

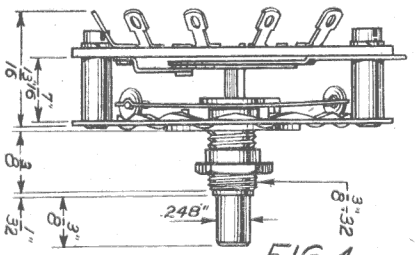


FIG. 4

cannot touch two or more of the fixed terminals at a time.

Figure 4 shows a side view and more of the mechanical details of one type of multiband switch. Such details are only important from the viewpoint of being able to trace the circuits through the switches.

In Fig. 5 the same type of switch is shown as in Fig. 3 with one exception. In this case, there are two moving arms instead of one. These are marked *common* and might well connect to a control grid and tuning condenser of a RF stage. Then there are five other *non-moving* terminals to which each of the moving arms can connect. To these fixed terminals could be connected various values of coils and condensers for the different frequency bands to be covered—one moving arm and five fixed terminals for an RF tube and a similar arrangement for an oscillator tube—thus five frequency bands could be covered. That is the way multiband switches work. Many radio men often refer to the circuits connected to the fixed terminals as *channels*. This is shown alongside the wires which connect to the fixed terminals of Fig. 5.

So far only *single deck* switches have been considered. Such a switch would not do in the average all wave receiver because a single deck switch having as many as eleven or twelve terminals is often required for switching the antenna coils alone. Generally, a separate deck is required for each grid and plate circuit in the RF tuning system.

To overcome this requirement for more than one deck, design engineers mounted several of them together. Typical examples of multiple deck switches are shown in Figs. 6, 7 and 8. These multiple deck switches are exactly like the single deck switch described for Fig. 3. The only difference is that they are held together with mounting studs (but each deck insulated from the other) and the center metal shaft is longer. This permits *one motion to operate all decks.* As many as ten or more decks are often operated in this way.

In a diagram showing a complete all wave tuning system the entire arrangement may look complicated. However, when broken down or separated each circuit is easy to trace. A certain amount of patience and time is required for this, but it is the only way to completely understand such complex circuits.

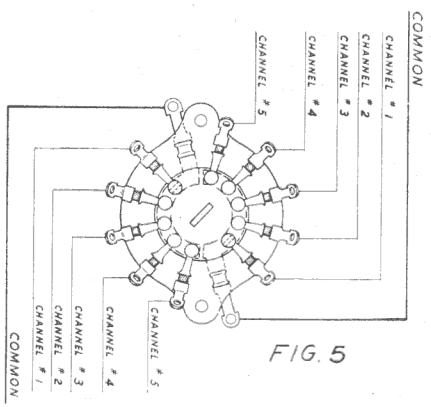


FIG. 5

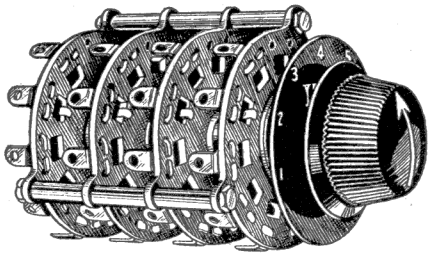


FIG. 6

CIRCUIT ANALYSIS

The circuit of the RF tuning system of a simple, inexpensive, TRF, dual-wave receiver is shown in Fig. 9. The tuned grid coils of both the RF and detector stages are tapped so that the lower section of each secondary coil (L3 and L6) may be shorted out of the circuit. A smaller amount of inductance L2 and L5 will then tune to a higher frequency with the same tuning condensers. The position of these taps on the coils determines the frequency bands to be covered. Actually coils L2 and L3 may be separated so that when L3 is shorted out, its windings will not be magnetically coupled to L2 and will not produce high frequency losses in this way. The same is, of course, true of L5 and L6. Better results would be obtained by using separate antenna and plate coils, but this would hardly be justified in an inexpensive receiver of this kind. In some cases a single tapped coil is used for L2-L3 and L5-L6. The two switches are ganged together—that is, one knob operates them both simultaneously although they have no common electrical connections except to ground.

The superheterodyne circuit has almost universally replaced the TRF receiver, although the latter is quite practical for short wave reception. Successful fixed frequency short wave receivers have been laboratory built for frequencies up to 300 MC of the TRF variety, but with low gain per stage. Gang tuning of TRF receivers at these frequencies is not practical.

The simplest possible dual-wave switching for a small superheterodyne is shown in Fig. 10. A section of the RF coil is switched out of the circuit by means of a double pole, single throw switch allowing the RF tuner to tune to a higher frequency. No change is made in any other circuit. In this case, the second harmonic of the oscillator stage beats with the received signal producing the correct IF. This, of course, is very crude. It cannot

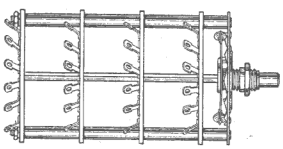


FIG. 7

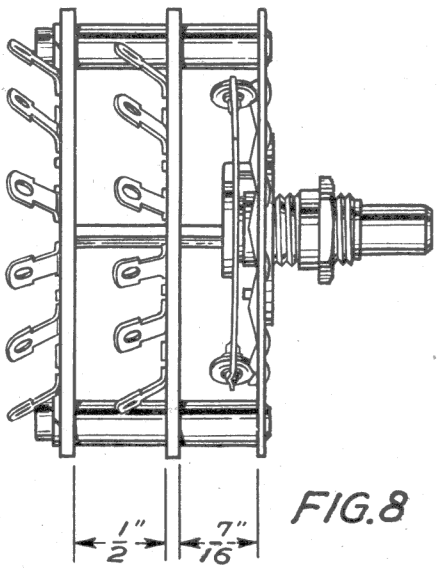


FIG. 8

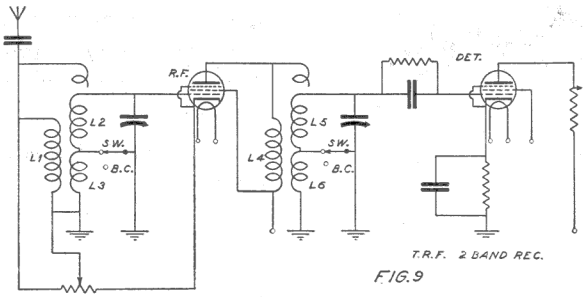


FIG. 9

prevent station interference to any great extent and cannot be aligned perfectly. Again such an arrangement is only desired for a small, *inexpensive receiver.*

A simple type of circuit for better operation is shown in Fig. 11.

The coil tap system is used here, also, but the oscillator coil is tapped as well as the RF coil. The fundamental oscillator frequency is used all of the time and tuning alignment is facilitated by this method of design. In addition to this, any short wave band may be chosen as the oscillator and RF circuits may be tapped at other points as desired.

The operation of these switches is obvious—they are simply single pole, single throw switches and are operated by one knob. While the designs thus far mentioned are suitable for two band operation, they would not work very well for more than two bands. A much better two band arrangement is shown in Fig. 12. In this design, separate coils are used throughout for each band. The switch terminals are lettered A and B—A for one band and B for the other band. Note this switch has four sections indicating it is of the four deck type—the dotted lines show the moving arms of the switch assembly and the two main tuning condensers.

Deck 1 of the gang switch changes from one antenna coil to another, deck 2 of the switch changes from one grid coil to another, deck 3 changes the oscillator grid tuned coils and deck 4 changes the oscillator plate coils. Note in Fig. 12 that the stators of the two main tuning condensers (C1 and C2) are connected to the switch arms, 2 and 3, and are thus used in tuning each set of coils. The two oscillator plate coils are, of course, untuned. The effect of one coil upon another when coupled makes it advantageous to use separate coils as shown here to preserve the highest possible circuit efficiency

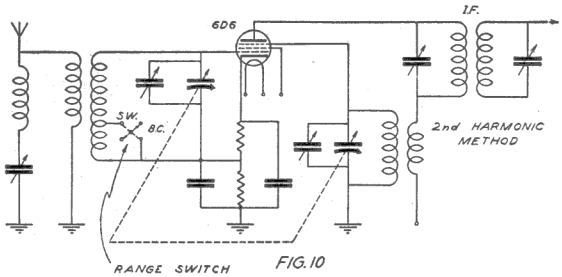


FIG. 10

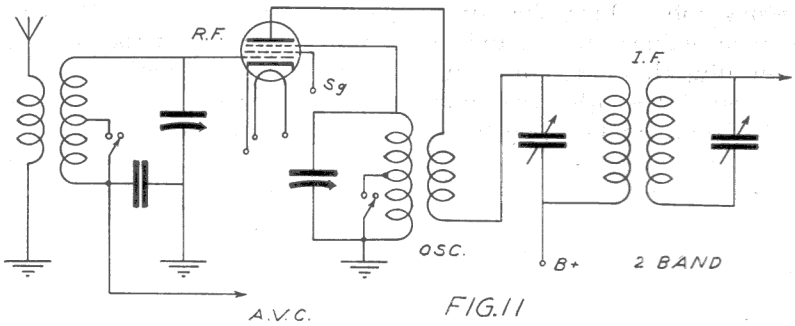


FIG.11

as well as the best tuning alignment.

The actual coil construction is of some importance and interest. For some time coils for the broadcast band have been wound on ¾ inch and ⅞ inch forms and, of course, have had 90 to 110 turns of wire on their secondaries (tuned section) of No. 26, 28 or 30 wire. This made them sufficiently short in length for good efficiency and permitted the use of a convenient and economical metal shield around them. These are, of course, only average figures as there are both smaller and larger coils in use.

Now consider the inductance situation for these frequency bands. You know that the lowest frequency of each band will make use of substantially the same total circuit capacity and that one band will start slightly below where the next lowest one stopped. The frequency as the result of the inductance value for one band and that for the next band will be at a ratio of 1 to 3 average and the inductance ratios, therefore, the square of them or 1 to 9. Now, if the general shape of a coil or the size of wire, insulation, etc. are not changed, the number of turns squared would be proportional to the inductance; hence, if a coil had 90 turns of wire for the broadcast band 540-1600 KC, it should have 90/3 or 30 turns for the next band, 1600-4500 KC, etc. This is not true, however, as it has been found most effective to use a coil of smaller diameter for short wave bands ranging from ½ inch down to ¼ inch in some cases.

The complicated factors of distributed capacity, switching leads, shielding, etc. make the determination of coil values of this type a

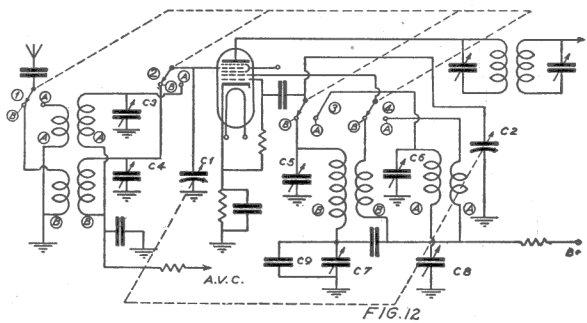


FIG.12

laboratory job. Once the correct inductance values are found experimentally, they can, of course, be duplicated for other receivers. Each different model receiver has its individually engineered coil and switching system ,and it may take from a few days to a few weeks to work out all the details for a production line receiver.

Referring again to Fig. 12, note that when section 2 of the switch is turned to band A, condenser C3 is in shunt with the condenser C1. Condenser C3 is, therefore, a very small trimmer condenser for aligning the RF circuit to the signal for any position of C1. Likewise, for this band (A) condenser C6 (connected to section 3 of the switch) is the oscillator high frequency trimmer and C8 is the oscillator low frequency padder. When the switch is turned to band B there is an equivalent set of condensers —C4 the RF trimmer, C5 the oscillator high frequency trimmer and C7 the oscillator low frequency padder. This last condenser (C7) has a *fixed shunt* condenser (C9) which makes up the major portion of the padder capacity, C7 being only the variable portion of it. In this way the tuning adjustments of the entire circuit for one band will not affect those of another. All bands may thus be independently aligned or adjusted.

The same IF is used for each band, and hence from the first detector on to the speaker and power supply an all wave receiver may be identical with any single band receiver. An all wave receiver differs from a single band receiver only with respect to the RF and oscillator circuits. Coils for the individual bands are separately shielded or placed at right angles to one another or are adequately separated to prevent undesired coupling between them. The leads from the switch to the coils are as short as possible and the adjustable condensers are either enclosed in their respective coil shields or are mounted adjacent to them on small isolantite or fabric squares. In every other respect the circuit is conventional in circuit design and operation.

In some cases the addition of another band of frequencies to a receiver is done in a simplified manner as in Fig. 13 by eliminating the first stage or RF amplifier and bringing the signal directly into

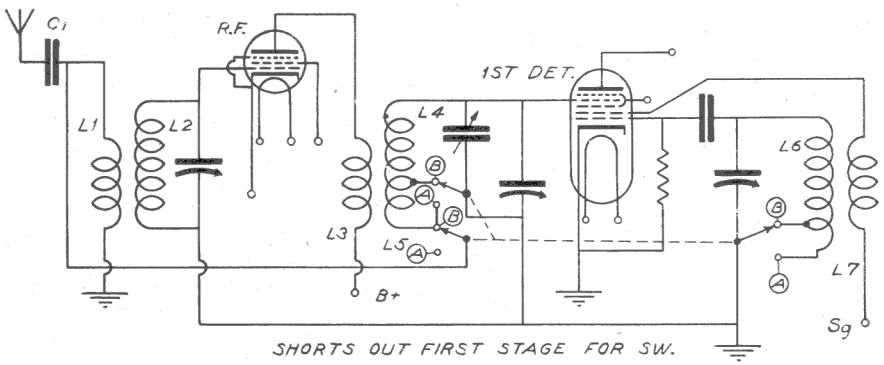


FIG. 13

the grid of the first detector. A great deal of switching is avoided in this manner. For example, with the three decks of the switch shown in the B positions of Fig. 13, the signal enters the lower end of the coil L5, directly from the antenna coupling condenser (C1) and joins a ground connection at the tap through the switch terminal (B) between L4 and L5. The signal also goes through L1, is induced into L2, but is not very strong in L3 because L4 with its tuning condenser is not tuned to the same frequency to which L2 is tuned. The preamplifier or RF circuit is, in this case, *useless* for the short wave signals. The oscillator is made to perform at the proper high frequency by switching the A section of L7 out of the tuned circuit and using only section L6.

A larger all wave or multiband receiver is simply an extension of the essential ideas brought out for Fig. 12. In this way, three, four and five band receivers may be successfully designed. The switching systems may be somewhat simplified electrically through the application of certain short cuts. These short cuts include the use of one coil where possible for two adjacent bands or by using two coils in series (where possible) if the operating efficiency is not impaired thus avoiding an extra coil.

Such circuits, however, are, as a rule, very confusing to anyone analyzing the circuit. Most of this confusion is due to the *lack of standardization in drawings of switching systems.*

VARIATIONS IN SWITCHES

Before taking up the study of practical circuits as used by the various radio manufacturers you should understand that not all switch systems are alike even though they may appear similar to one another in a schematic diagram. Manufacturers are continually varying switch applications and the way they show them in diagrams. Thus, it is up to every radio man to develop his own technique in learning to read and follow all wave switching systems. One thing that should always be remembered about these switches is that when a movable arm or terminal is visualized as moving, all other corresponding arms on the other switch decks also move. This means that you cannot consider the action of one deck alone in a multiple deck switch, but you must consider what occurs at the other decks as well. With respect to a single deck some diagrams show the moveable element of the switch as being very wide—it extending over and shorting across several other fixed or non-movble terminls of the same deck. This wide movable part of the switch is called a *shorting shoe.* The reason for it will be brought out later on where it will be shown that it is very desirable to short circuit parts not in actual use. This prevents inter-coupling between coils and thus one not in use cannot absorb energy from another which is in use.

This type of switch is also made in the shorting and non-shorting types as previously mentioned. The shorting type is used most often to prevent loud noises from the speaker as the band switch is turned from one band to another.

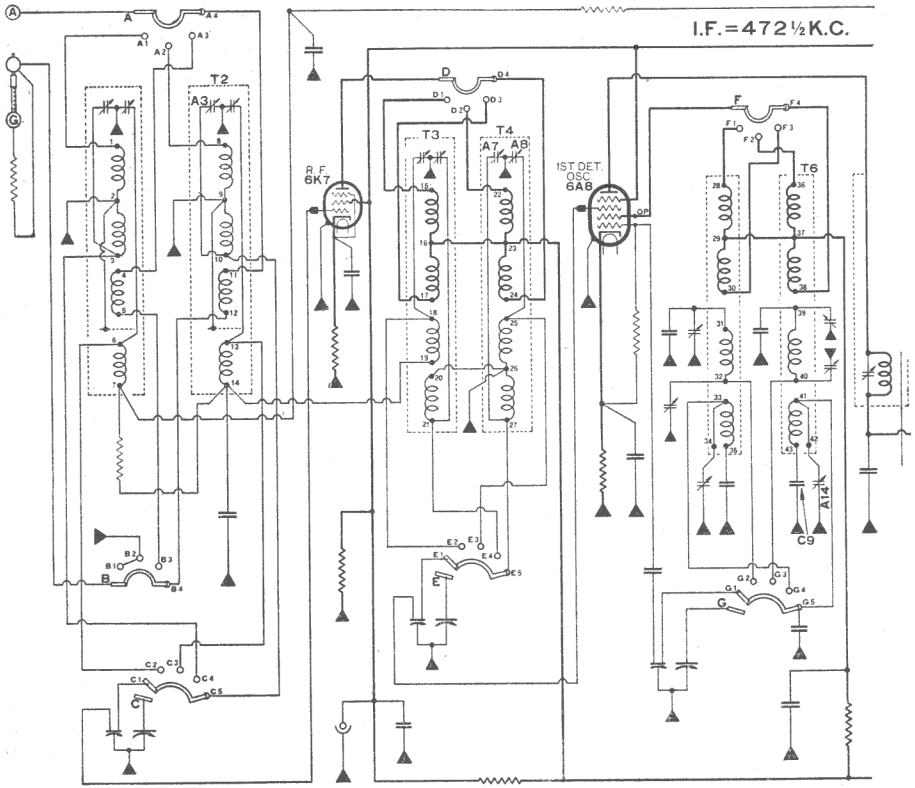


FIG. 14

In this type of switch the moving arm touches the next adjacent terminal before opening the circuit of the preceding terminal. In this way loud switch noises are avoided.

ACTUAL RECEIVER CIRCUITS

In Fig. 14 is shown the switching system of the Atwater Kent model 810 all wave receiver. It uses a four band RF and oscillator tuning system with a seven deck switch. The circuit is designed to tune from 540 to 18,000 KC. The switch decks are marked A through G, and each switch terminal is lettered and numbered for reference. The movable part of the switch consists of the semi-circular segment with an arm extending. At deck A, for example, the switch arm extends to the right. The left member connected to the antenna post remains stationary. It is a sliding contact to the semi-circular part and is always electrically connected to the switch arm in any of its positions. Although the antenna at terminal A is shown connected to A4, it may also be connected to A3, A2 or A1. The other switch decks B, D and F are identical to A, but decks C, E and G are slightly different.

The switch arm for the C section is always in contact with the extended terminal C1. It does not

touch the other extended terminal at C. When the switch arm is turned to C4, the circular part of the switch joins C1 and C, thus connecting the two variable condensers immediately below in parallel. This connection also holds for the C3 and C2 positions of the switch. Switch decks E and G are just like C for all of them control the tuning condensers.

Now consider the action of the entire switch (all decks) for the positions of the switch arms shown in Fig. 14. The antenna circuit is from A to A4 to terminal 11 on the third coil. It then continues through this coil to 12, to B4, to B and to ground. This third coil (11-12) is magnetically coupled to all of those in the RF transformer compartment T2 shown in dotted lines. All coils in this section except (9-10) may be traced to free ends and hence are not used. Terminal 9 is connected to the metal chassis and to an intermediary shield between the two lower coils to prevent capacity coupling. Terminal 10 is connected to trimmer A3 and switch terminal C5. The connection continues through the switch to C1 to the main RF tuning condenser and to the control grid of the first RF 6K7 tube. This much of the circuit is simply a conventional RF input circuit.

The plate of the 6K7 tube through switch D and D4 connects to coil 24-23 and terminal 23 is connected to the common high voltage plate supply. Since all other coil contacts are open, both in transformers T3 and T4, plate current must flow through coil 24-23. Coil 22-23 is obviously another primary and coil 25-26 is open at one end. This leaves coil 26-27 as the secondary used for the band under consideration. All the coils in T4 are magnetically coupled.

Coil 26-27 of section T4 is grounded at terminal 26 and to its terminal 27 is connected the trimmer A7. Entering the switch at E5, the connection may be traced to E1, the second tuning condenser of the gang and to the signal control grid of the 6A8 first detector oscillator. The plate of this tube goes to the first IF primary.

For the band under consideration, the oscillator coil is 37-38 tracing from the oscillator plate OP through deck F to F4 and coil terminal 38. Coil 41-43 is the oscillator grid tuning coil having a fixed padding condenser C9 and a trimmer A14. As in the other shielded compartments, all components within T6 are magnetically coupled. The foregoing has described the action of the switch for the highest band of frequencies which the receiver can receive. By turning the seven deck switch to the next lowest band, the following connections are made:

Switch	Terminal	Coil
A	A3	4-5
B	B3	4-5
C	C1, C4	2-3
D	D3	16-17
E	E1, E4	20-21
F	F3	29-30
G	G1, G4	33-35

In the same manner you can trace the connections for the other bands by following the switch action. Note that deck B terminals 1 and 2 are simply grounded and not used. The other connection

to B of deck B permits the use of a doublet antenna if desired for the high frequencies.

The circuit of another four band receiver (Philco 37-660) is shown in Fig. 15. Band 1 tunes from 532 to 1720 KC, band 2 2.3 to 7.4 MC, band 3 7.35 to 11.6 MC and band 4 11.5 to 18.2 MC. This receiver is somewhat more complicated than the one in Fig. 14. It requires a nine deck switch with two arms and four positions per deck. Note eighteen separate switch symbols are shown in Fig. 15 but there are two switches per deck, making a total of 9 decks. For each band there are eighteen circuit changes made. Switch arms A9 and A10 (same deck) connect the two ends of four different antenna coils to the doublet antenna. The various connections are simple and obvious as you will find when the circuit is traced. Each of the four secondaries are connected to the control grid of the 6K7G tube and to the first main tuning condenser through switches C8 and B9. This makes possible the connection of a series padder condenser 6C for the lower secondary coil covering the 11.5 to 18.2 MC range. The series padder condenser 6C and the shunt trimmer condenser 6B serve to give the tuning at high frequencies a *band-spread* characteristic. This means simply that this band is narrower than the other or a smaller section of it is tuned and the stations appear farther apart on the dial than usual. Note that this padding circuit is similar to the superheterodyne oscillator circuit which accomplishes the same electrical function with its series padder and shunt trimmer.

Switch arms C3, D11, F3 and J10 of Fig. 15 are *shorting switches* (the switch arm being in the form of a *shorting shoe* to all but one set of fixed terminals of the switch) for the purpose of eliminating the effects of free end or *dead end* windings on coils which are not in operation for a particular band. They short out every terminal *not in actual service.* For example, the switch arm of C3 carries with it the entire metal ring (grounded through the AVC), shorting C1, C6 and C12 and grounding them through the AVC circuit. The top coil with terminal C7 of switch C3 is in use in the position shown in the diagram. Note an *open space* is left in the metal ring which allows this terminal to be connected to the top coil. Notice that each of these *shorting switches* (C3, D11, F3 and J10) allows only the terminals in use to be open, shorting all of the others. This prevents the coils not in use from absorbing energy from those which are in use. While the grid coils are shorted to the AVC return, the plate coils are shorted to B+. Like all the other switches described in this lesson these are independent switches but operated by *one control knob.* To get a mental picture of their action, just imagine these entire metal rings turning to the left, freeing one contact at a time, and you will have a good understanding of the operation of this switching system.

The switching system for the signal grid of the 6A8G detector-oscillator tube in Fig. 15 is further complicated by introducing capacity coupling from the first RF tube to equalize the gain for the

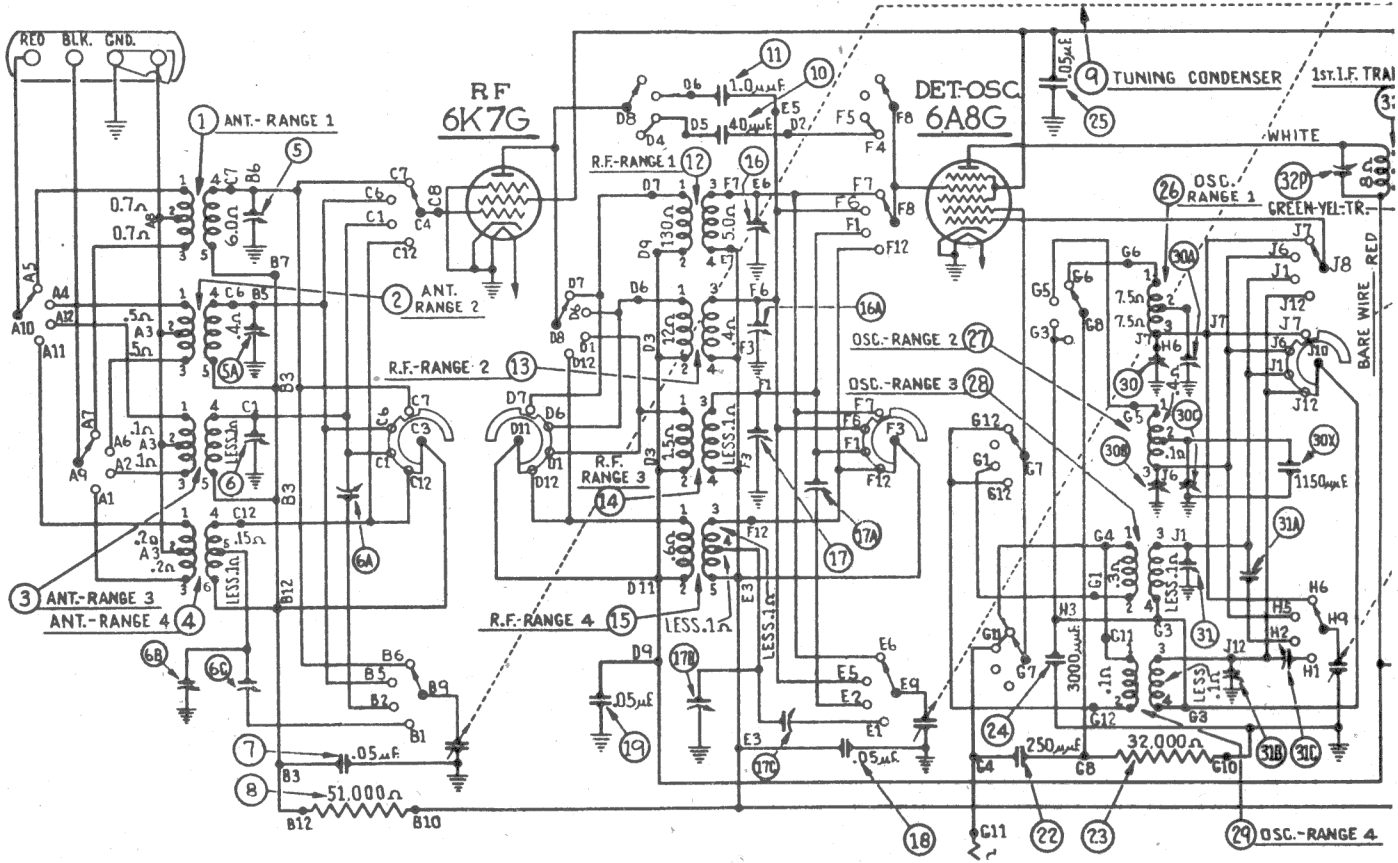

RED
BLK.
GND.
RF
6K7G
DET-OSC.
6A8G
1 ANT.- RANGE 1
2 ANT. RANGE 2
3 ANT.-RANGE 3
4 ANT.-RANGE 4
5
5A
6
6A
6B
6C
7 .05μF
8 51.000Ω
9 TUNING CONDENSER
10
11
12 R.F.-RANGE 1
13 R.F.-RANGE 2
14 R.F. RANGE 3
15 R.F.-RANGE 4
16
16A
17
17A
17B
17C
18
19
22
23
24 250μμF
25 .05μF
26 OSC. RANGE 1
27 OSC.-RANGE 2
28 OSC.-RANGE 3
29 OSC.-RANGE 4
30
30A
30B
30C
30X 1150μμF
31
31A
31B
31C
32P
WHITE
GREEN-YEL.-TR.
BARE WIRE
RED
1st.I.F. TRA
0.7Ω
0.7Ω
6.0Ω
.5Ω
.4Ω
.2Ω
.2Ω
.15Ω
LESS.1Ω
130Ω
12Ω
4Ω
1.5Ω
LESS.1Ω
LESS.1Ω
1.0μμF
40μμF
5.0Ω
4Ω
3000μμF
32,000Ω
7.5Ω
7.5Ω
.1Ω
.3Ω
LESS.1Ω
LESS.1Ω
.05μF

FIG.15

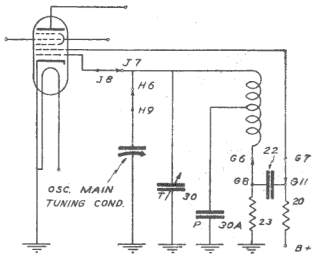


FIG. 16

various bands. Circuit operation conditions change for a number of reasons for various frequencies and their characteristics must be met with adequate provisions. Condensers 10 and 11 provide capacity coupling for three bands as shown by the diagram. Condensers 6A and 17A are for expanding the third range, thus separating the position of stations on the dial. A trimmer is provided for each tuned coil as well (5, 5A, 16, 16A, etc.).

A better understanding of the oscillator circuit may be had by referring to Fig. 16. This shows the circuit as the switches would connect it for the positions shown in Fig. 15. Feed-back is obtained by capacity coupling through condenser 22 above the oscillator grid leak resistor 23. The second band operates just like the first one, and for the first band the lower oscillator coil is shorted. For the third band, with reference to Fig. 15 again, the upper plate coil of the two is in series with the oscillator plate (second grid of 6A8G) and, of course, inductive feed-back is employed.

In connection with the oscillator tuned grid circuits for the two high frequencies (two lower coils) condensers 31A and 31C Fig. 15 are actually series padding condensers, the band spread requirements being met through the use of condenser 24 for both bands. For each of these bands the correct beat note frequency is formed and, as usual, the plate circuit of the 6A8G tube is tuned to this frequency.

It may strike you that the circuit of Fig. 15 is very crowded and difficult to read. That is true, but, at the same time, it must be remembered that the manufacturers try to include as much information as possible about their products to make repair and replacement of parts accurate and easy. In the modern, complex radio circuit, this is difficult to do, and for that reason and because of limitation of space in printing circuits like Fig. 15, they will always appear complex and crowded. The radio man soon learns to trace even the most complex of circuits by concentrating on a portion of it at a time. The rest of the circuit is simply not considered for the moment. You should learn to develop this technique as soon as possible and there is no better way to do it than to practice at tracing multiband receiving circuits. Note Fig. 15A shows the details of the coils and switches appearing in Fig. 15.

Considerable simplicity may be obtained in a switching arrangement by making use of every possible switch terminal at every position. When one terminal is open for one coil, *the same terminal* can often be used for another purpose. The system for three band switching, as in Fig. 17 for example, is one of the simplest used. This is a part of the circuit of the Montgomery Ward receiver models 62-235 and 62-248. First consider the 11

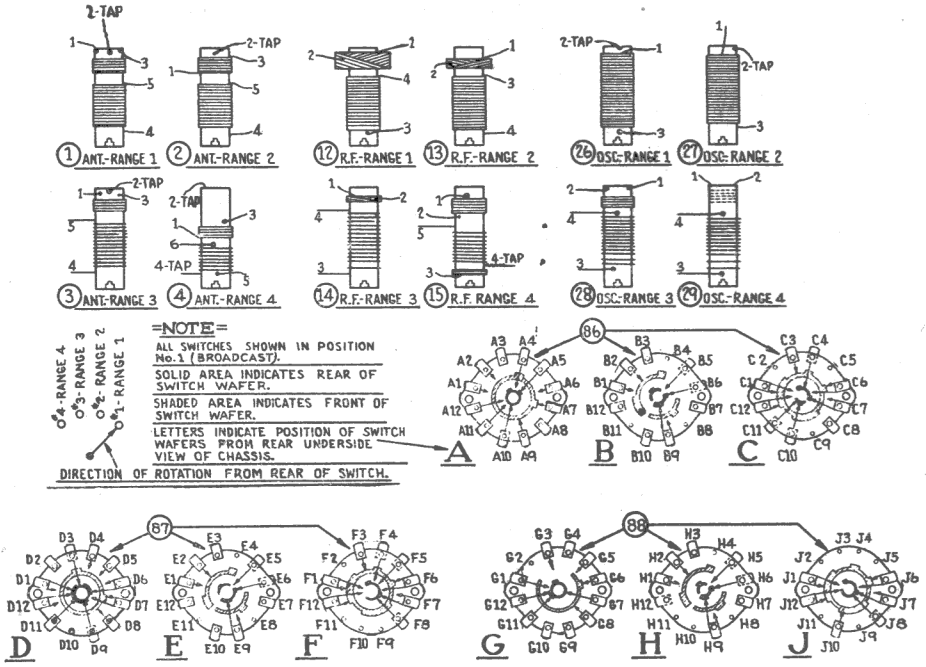


FIG. 15-A

switch terminals which the switch S is making in the position shown. The signal from the antenna simultaneously feeds four circuits—(1) a small capacity coupling (C1) to the control grid coil L3, (2) an antenna coil L6 in transformer T2 inductively coupled to the lower section of the grid coil L5, (3) another antenna coil (L1) coupled to another section (L2) of the multiple grid tuned coil and (4) open end windings L7 and L8 in transformer T1. The latter furnishes uniform coupling over a wide range of high frequencies in conjunction with the antenna coil L6.

Since all of these antenna connections are active it becomes a question of determining which input is effective by checking the control grid connections of the 6F7 tube. The junction of coils L2 and L4 is grounded through terminals 8, 9, 10 and 11 of the switch thus shorting L4 and L5 making them inoperative. The only antenna connections which are effective are, therefore, the top antenna coil (L1) and the small capacity coupling (C1), which together provide fairly uniform coupling for the high frequency band. The RF tuning condenser indicated by dotted lines—marked (C) tunes the largest section (L2) of the two section grid coil, the remainder of the tuning capacity being provided with the trimmer (T) for the highest possible L to C ratio of the circuit and for slight band spread characteristics. The lower right sector of the switch (8, 9, 10 and 11) individually shorts the two

coils L4 and L5 (for lower bands), and shorts the antenna coil L6 (through L1) as well.

For the high frequency band the top (two section) part of the switch (5 and 6) grounds the junction of the two cathode feed-back coils (L13 and L14) of the oscillator section of the 6F7 tube, thereby shorting the lower coil L14 as its lower end is permanently grounded. The two cathode coils (L13 and L14) are to the lower right in transformer T3. The top oscillator grid coil (L9) comes into action, the lower two (L10 and L11) being shorted to ground through terminals 2, 3 and 4. Since all of the coils for the oscillator are all coupled, both the plate and cathode coils for each band furnish feed-back to the grid coil for self-oscillation. The plate coil L12 for the oscillator remains in the circuit for every band change.

The switch is rotated counter-clockwise for lower wave bands. The inner circular sectors of the moving part of the switch move with the arrows pointing outward while the arrows pointing inward remain stationary. The arrows pointing inward slide on the circle sectors making continuous contact with them while they are in positions within their angular range. Positions 1 and 2 of the switch are shown in Figs. 18 and 19. Note the switch S in Fig. 17 has three movable sections which are entirely insulated from each other. One moving section corresponds to treminals 2 and 4, the second moving section consists of terminal 5 only while the third moving section corresponds to 8 and 11. Note how the movable elements change positions in Figs. 18 and 19. The three circular segments of the switch in Figs. 17, 18 and 19 are known as shorting shoes and may be indi-

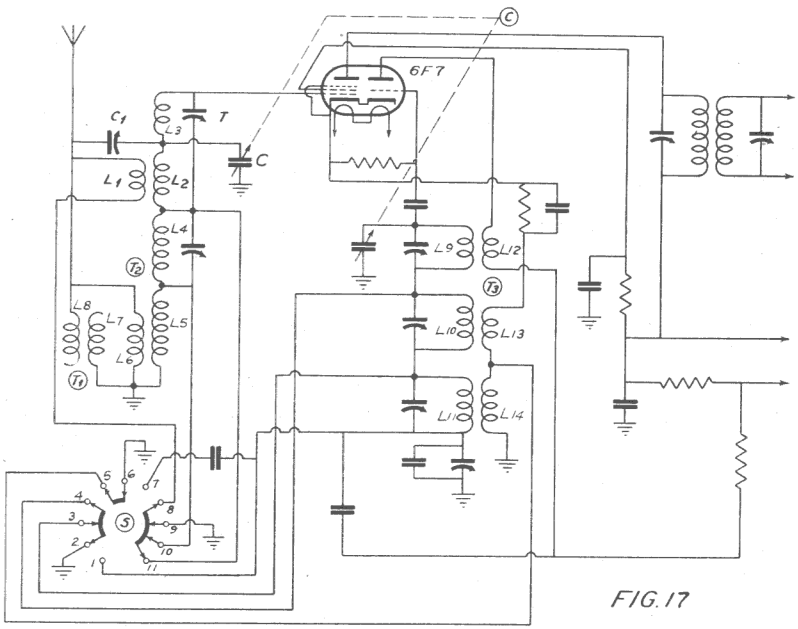


FIG. 17

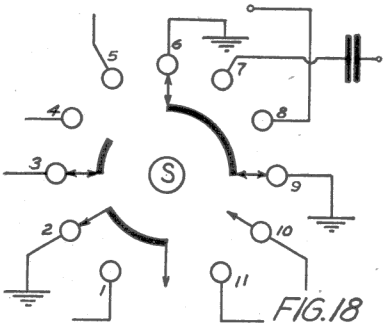


FIG. 18

POSITION 1

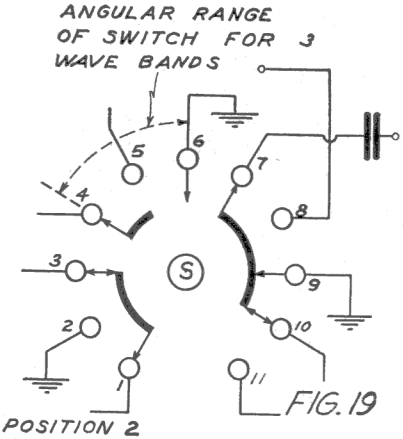


FIG. 19

POSITION 2

cated differently in the diagrams of various radio manufacturers.

Still another type of switching system is shown in Fig. 20. This is the Belmont model 1070. Bear in mind that multiband switches may not only be electrically but mechanically identical but are drafted or drawn in different ways by the various radio manufacturers. The switch S of Fig. 20 is a rotating three position switch but is indicated on the diagram as a set of sliding contacts. The rectangular blocks (A, B, C, D, etc.) form a common circuit and make contact with the projecting T sections of 1, 2, 3, 4, 5, etc. The switch is shown in the broadcast position in Fig. 20.

In the first position of the switch the following connections are made: 1 to B, 5 to I, 6 to J and 7 to K. When the rectangular blocks

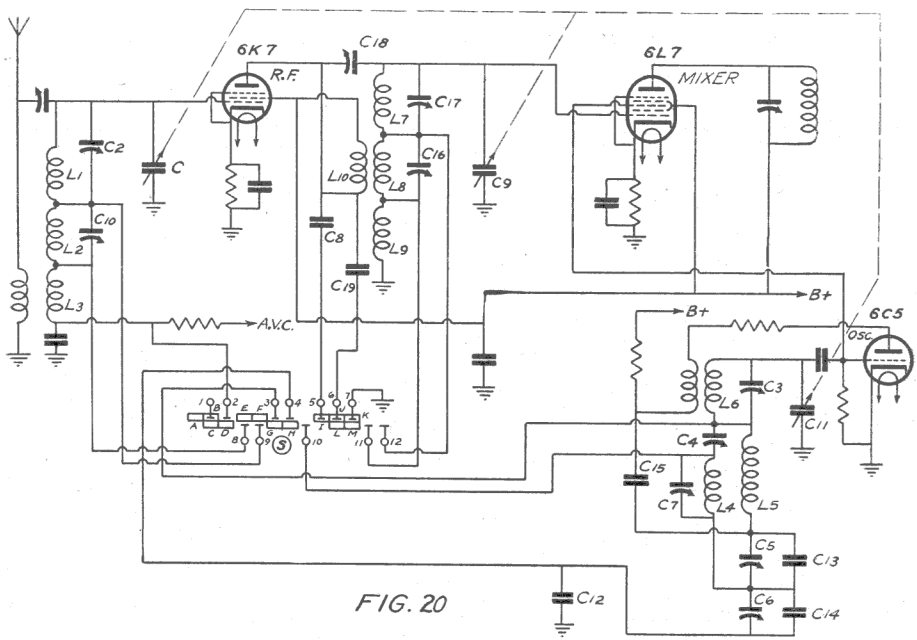


FIG. 20

move to the second position to the right, the following connections will be made: 1 to A, 2 to B, 3 to F, 6 to I, 7 to J, 8 to D, 10 to H, and 11 to M. On the next and final position of the switch the rectangular lettered blocks in Fig. 20 move over two positions from that shown in the diagram, and the following connections are made: 2 to A, 3 to E, 4 to F, 7 to I, 8 to C, 9 to D, 10 to G, 11 to L, and 12 to M. Now note that A, B, C, and D are common or form one moving element of the switch. The same is true for E, F, G, H, and for I, J, K, L, and M. It should now be clear that when the switch is in position 1 that the tuning condenser C will be across all three coils consisting of L1, L2 and L3 to tune the broadcast band and that part of the switch for the RF stage will be open. On the 1st detector section of the switch 5, 6, 7, I, J, and K will form a common circuit to ground. Terminals 10, 11, and 12 will remain open. On the second position 1, A, 2, B, 8, and D will form a common circuit to short L3, leaving L1 and L2 to be tuned by C. On the next section of the switch 3, F, 10, and H will form a common circuit and the effect of this action is to short series condenser C4. This permits L6 and C3 (in parallel), L4 and C7 (in parallel) and these in series with C6 to tune from 1720 to 5500 KC. L5 and C5 in series will be in parallel to L4 and C7, the values of all of which are apportioned to tune to the correct band of frequencies. The remaining section of the switch for this band will form a common circuit as follows: 6 to I, 7 to J, and 11 to M for the input to the 6L7 mixer. The effect of this is to disconnect one end of C8 and short L9 to ground, leaving L7 and L8 to be tuned from 1720 to 5500 KC by C9.

The third and final position for the switch permits it to tune from 5.5 to 18.1 megacycles. Thus the rectangular blocks for the switch move over two positions to the right. With reference to the A, B, C, D, section 2, A, 8, C, 9, and D form a common circuit to short L2, L3, and C10. This permits C to tune L1 and C2 as the high frequency trimmer. The next section of the switch E, F, G, H, forms the following connections: 3 to E, 4 to F, and 10 to G. This actions shorts C4, L4, C7, L5, C5, and C6 leaving L6, C3, and C11 to act for the 5.5 to 18.1 megacycle range. Condenser C12 acts as a low frequency fixed padder in this case. The combination of C5, C13, C6, C14, and C12 all act together as a padder for the broadcast band. C5 has more effect on the broadcast band, while C6 has more effect on the 1720-5500 KC band. C13 is the fixed pader for the broadcast band with C14 the fixed padder for the 1720-5500 KC band. C15 is a bypass condenser for the oscillator plate circuit. The I, J, K, L, M

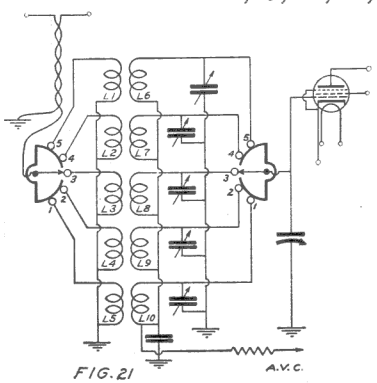


FIG. 21

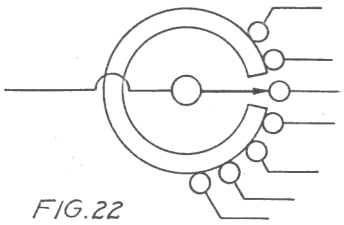


FIG. 22

section of the switch shorts L8, L9, and C16, permitting L7, C17 and C9 to tune the mixer tube input circuit to the 5.5 to 18.1 megacycle band. Condenser C18 provides capacity coupling from the plate of the 6K7 RF tube to L7, L8, and L9. Condenser C8 with L10 forms a trap circuit to interfering frequencies at or near the IF of 465 KC. The winding of L10 is coupled to L8 with the screen grid of the RF tube acting as an anode in this case. Note that both C8 and C19 act for the broadcast band, but only C19 is used for the 1720 to 5500 KC band. Both C8 and C19 are out of the circuit for the 5.5-18.1 MC band. The magnetic coupling of L10 to L8 is used for the first two bands, but it is not in use for the 5.5-18.1 MC band—all coupling in this case being furnished by C18.

In Fig. 21 is shown a common

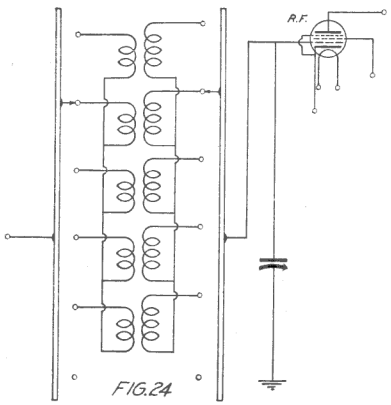


FIG. 24

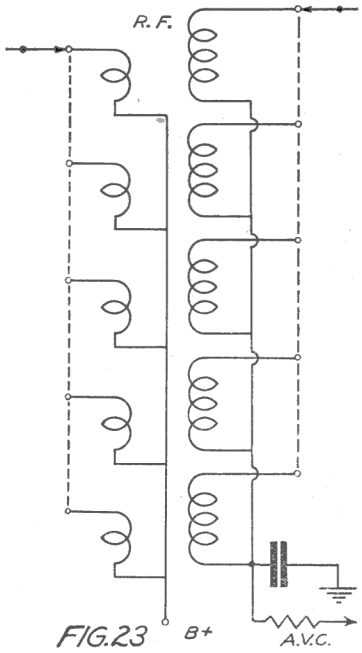


FIG. 23

type of switch which connects to one terminal at a time, shorting all others to one another. The operation of this switch should be obvious—note that it is set for band three using L3 and L8. Position 5 makes use of L1 and L6, etc. The circuits for the other switch positions may be traced from the diagram. This switch is popularly known as the fan type switch because of its resemblance to the shape of a fan. It is also known as the shorting shoe type. The same principle may be indicated by a contact ring as in Fig. 22. Still other types of switches are indicated simply with an arrow as the moving member and a number of contact points in line as in Fig. 23.

In this type of drawing a conductive track for the moving arrow terminal of the switch is often included, making the system appear as in Fig. 24. Regarding the

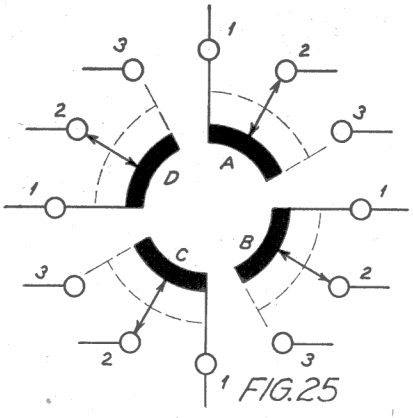


FIG.25

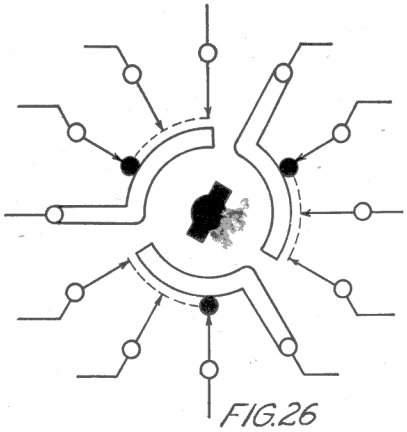


FIG.26

switch symbol in Fig. 25, the double arrows move simultaneously, making connections with the arc segments A, B, C, and D as shown. Note each section of this switch has three positions. In Fig. 26 the small solid circles move along the edge of the switch arm segments making contact with successive arrowheads or fixed terminals.

You will find certain combinations of many of the switching systems which you have studied in this lesson. Such combinations should not be difficult to understand if you will analyze each system carefully.

For convenience in checking and tracing circuits, it is often desirable to show the mechanical layout, terminals, etc., of a multi-element switch. A typical layout is shown in Fig. 27. This particular switch has six decks, each having two or more functions.

In the first deck there are twelve terminals riveted to a wafer insulating frame. Two of these terminals are not used (A7 and A12) while all of the others have a definite connection to make. Terminals A4 and A5 are switch arms and may be identified in deck A by their arrow connections making contact to the two base rings, one inside the other. These make permanent contact with their respective rings in any switch position. The elevated portions of these rings of slightly larger radius make contact with the other arrows from other terminals for various positions of the switch. The short arrows make contact with the elevated sections of the large ring and the long arrows

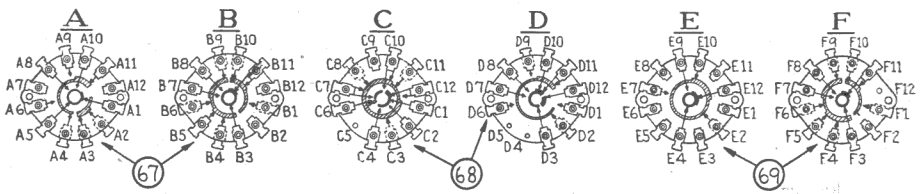
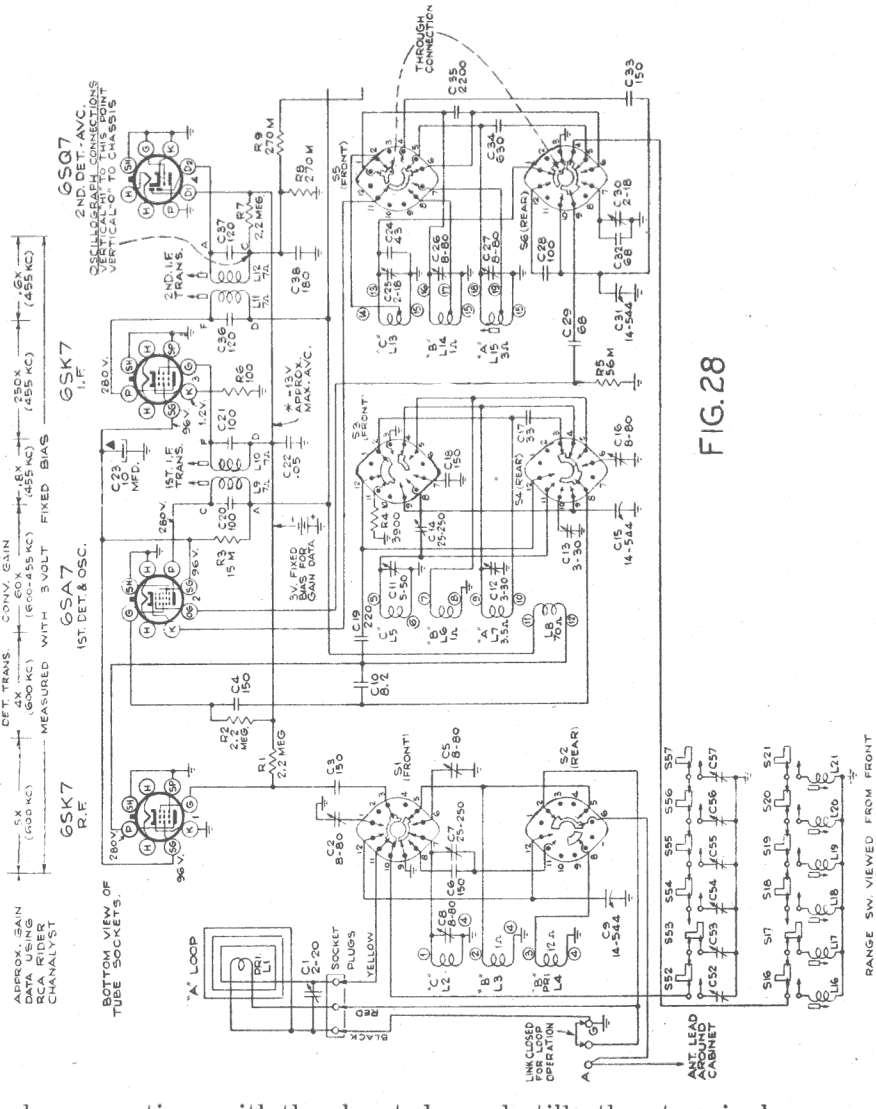


FIG.27



make connections with the elevated sections of the small inner ring. Note that the outer ring is split into two segments for independent circuit connections.

In each of the layouts these rings are turned to make the proper connections with the various terminals. Some of the terminals in Fig. 27 have two arrow heads, some terminals are blank and still other terminals are omitted altogether. The reason for such omissions is that no wiring is required for some of the decks at certain switch positions. Together with the schematic circuit, switch layouts are very helpful in identifying the terminals with the circuit connections for testing or analysis.

One popular system of mounting

multiband coils is to mount all of them with their axes parallel on circular bases and in stacks or groups surrounding the multi-terminal switch. The shorting of every unused winding takes the place of shielding each coil. The wiring and various capacities formed by turning the switch are compensated for by the trimmers for each band while the switch is turned in the position for that band. Still another system employs a rotating framework fitted with switch contacts and coils. As the switch is turned all the coils are moved, each one contacting the proper circuits when in position.

Figure 28 shows the tuning system of the RCA 211K model. This is a four band receiver with the following frequency ranges. Band A, 540-1600 KC; band B, 2.3-6.3 MC; the next band is called the *band spread* (BS) band and tunes from 9.35 to 7.75 MC; and C 11.7 to 15.4 MC. The band switch is of the six deck type. Note particularly the inner segments of the switch decks which are *shaded.* Note also each deck has two rotating arms with the exception of S4 which has one arm. Each of the arms has a certain odd shape which you should study—you will have to imagine how each of these arms come into contact with the fixed terminals of the switches because a diagram can only show the exact connections for one position of the switches. These switch symbols are typical of RCA receiver diagrams and many others. It will, therefore, pay you well to give them close and careful study. The switches have five positions and in Fig. 28 show the connections for

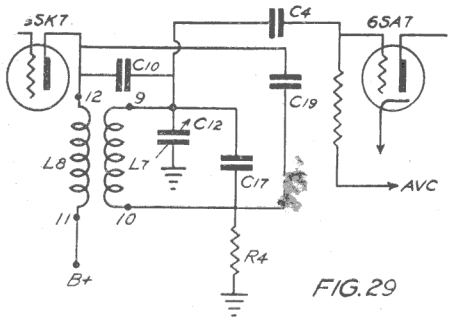


FIG. 29

push-button tuning. The details of the latter will be taken up in a later lesson. However, the band switch connections to the push-button tuner will be described in this lesson. If the push-button range of the band switch is called the PB position, the second position will be the A band, the third position the B band, the fourth position the BS (band spread) band and the fifth position is for the C band.

Referring to the position of the switch arms in the diagram, S1 and S2 control the input connection for the 6SK7 tube. The switch arms are shown in their maximum left hand positions. Thus from PB to band C the switch arms move from left to right or clockwise. S3 and S4 control the mixer coils and the movement of their switch arms is in the same direction as described for S1 and S2. S5 and S6 control the oscillator coils and these switches have the same action as described for the others. Be sure to understand how the switch arms move. S1, S3 and S5 are shown with front views and S2, S4 and S6 are shown with rear views. The rear view designation is given because the switch terminals are mounted on the rear of the switch insulating wafer instead of the front of it.

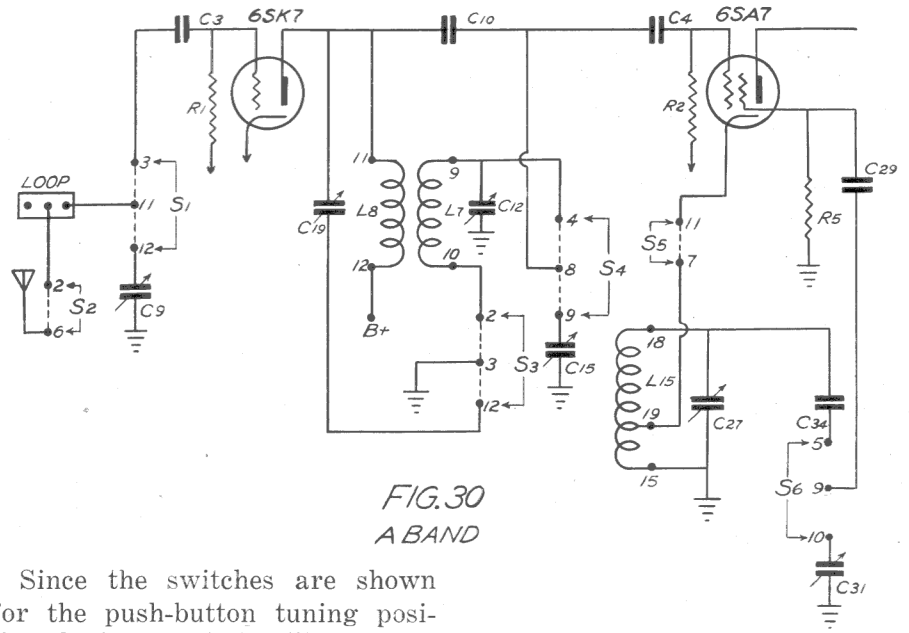


FIG. 30
A BAND

Since the switches are shown for the push-button tuning position the band switch will be in the PB position but this also corresponds to the A band position because the push-buttons work only from 540 to1600 KC. In this position, the loop supplies the signal energy, it being fed to 11 of of S1. The upper arm of S1 forms a common circuit of 3, 10 and 11 of the switch permitting signal energy to be fed to the RF tube. Note 10 of S1 controls the push-button tuning circuit. The switches in this case controlling S53 and C53 for the RF and S17-L17 for the oscillator —the mixer input not being push-button controlled. The other switch arm of S1 forms a common grounded circuit of 5, 7 and 9. S2 merely makes a common circuit of the antenna and loop. Terminal 6 of S2 may appear to be blank—the antenna band, however, connects to 6 and to the right hand arm of S2. The reason the lead to terminal 6 of S2 appears to go around the terminal is because of a special insulated clip on the switch wafer. In effect this may be considered a permanent connection at 6 of S2.

Next consider S3 and S4. First note the connections of L8—it is permanently connected in series with the plate of the RF tube and is coupled to L7 for the PB and A band. Also, C10 couples the plate of the RF tube to the grid of the mixer tube to improve coupling at the higher frequencies. Now note the connections of L7. Number 9 of this coil connects to 4 of S3 (forming an open end connection) and to 3, 4 and 8 of S4. The equivalent action of S3 and S4 is to from a tuned circuit between the plate of the 6SK7 and the grid of the 6SA7 as in Fig. 29. This form of coupling permits the omission of push-button tuning condensers for the input of the mixer tube — the push-buttons only having control of the input to the RF and oscillator stages. With a push button tuned circuit ahead of

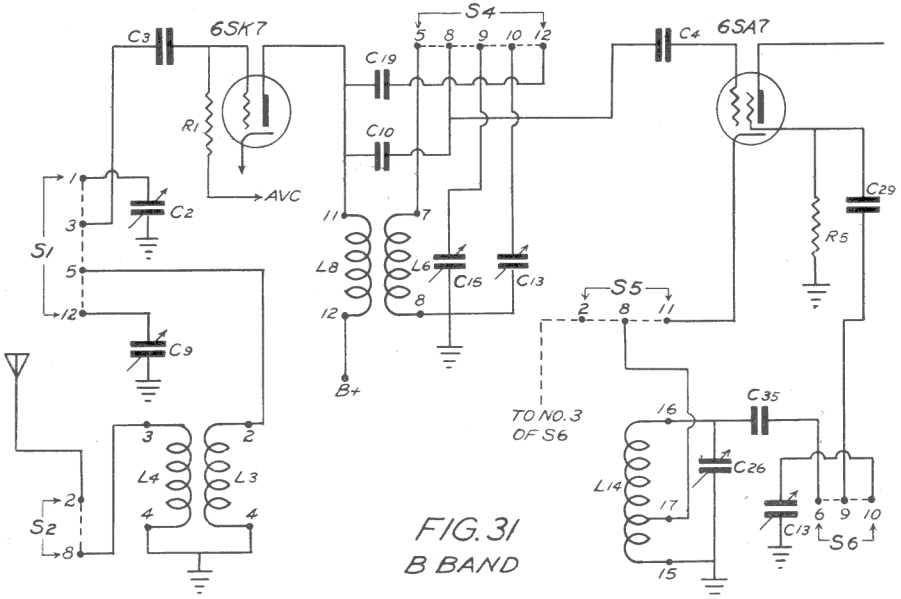


FIG. 31
B BAND

the mixer and one following it, enough resonant signal energy will get through the mixer input circuit without having it push-button controlled. Note condenser C15 (the mixer tuning condenser) is not used when the range switch is set to the PB position. The same is true for C9 and C31—the other two ganged tuning condensers. Thus for the push-button position of the gang switch, coupling and tuning for the input of the 6SA7 tube are provided by L7, L8, C12, C10, C19, C17 and R4. Resistor R4 is included to broaden the tuning of L7, C12 and C17.

Next refer to Fig. 30. This shows how the switch would connect the circuits for the A band. Note this represents the switch arms of Fig. 28 moved one position to the right. For this band, either the loop or an outside antenna may be used, depending on the way the *link* connection is made. In Fig. 28, if the *link* is tuned to the right, the loop is used, and if it is turned to the left, an outside antenna may be used. Note in Fig. 30 terminals 3, 11 and 12 of S1 complete the input circuit to the 6SK7 with 2 and 6 of S2 completing the antenna circuit. 2, 3 and 12 of S3 and 4, 8 and 9 of S4 complete the mixer input. 7 and 11 of S5 and 5, 9 and 10 of S6 complete the oscillator circuit. In order to avoid more confusion, the shorting action of the various switches is not shown. For the A band 6, 7 and 9 of S1 short L2, C8 and C5, 2 of S5 and 1 and 3 of S6 short L13, C25 and C24. These various units are all shown in Fig. 28.

Figure 31 shows the switch connections for the B band. 1, 3, 5 and 12 of S1 complete the input to the 6SK7 tube with 2 and 8 of S2 completing the antenna circuit. For the input to the mixer circuit 5, 8, 9, 10 and 12 of S4 come into use. For the oscillator circuit 2, 8 and 11 of S5 and 6, 9 and 10 of S6 are

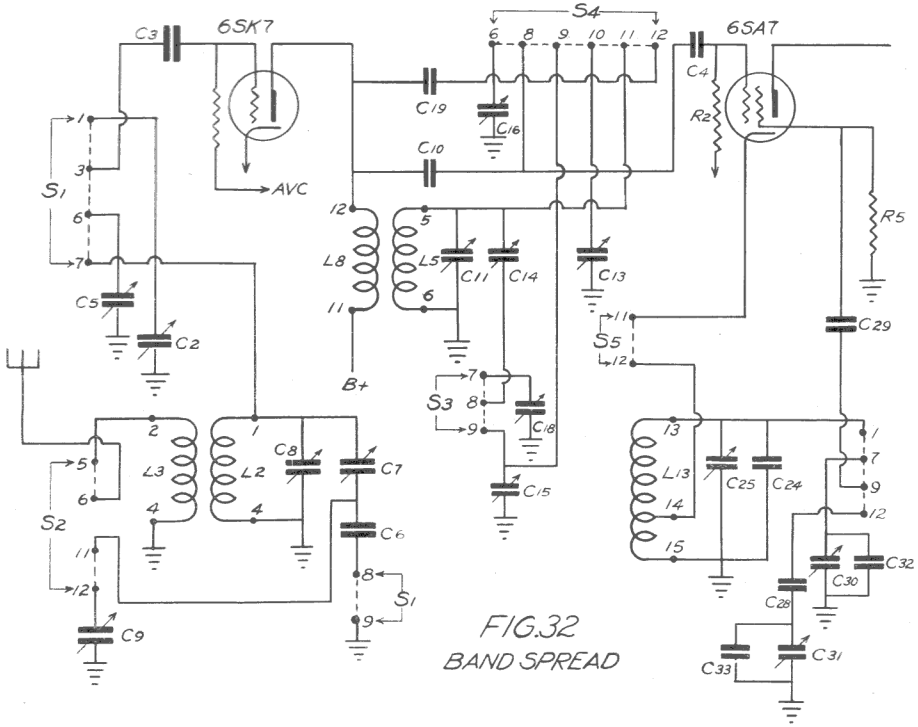


FIG. 32
BAND SPREAD

used. Note the dotted line connection from 2 of S5 in Fig. 31. For an explanation of this, refer to S5 and S6 of Fig. 28 and observe the notation "through connection." This means a metal rod extends from the deck of S5 to the deck of S6 making the switch arms involved common or forming one continuous circuit. Thus the dotted line from 2 of S5 in Fig. 31 means this connection continues on to 3 and 4 of S6. The shorting action for this band is as follows: 7 and 9 of S1 short L2 and C8, 2, 3 and 4 of S3 short L7 and C12 while 1, 3 and 4 of S6 short L13, C24 and C25.

Figure 32 shows the *band spread* switch connections. Extra capacities are added to the B and C band coils so as to cover a narrower range of frequencies than is covered for the other bands. Thus the stations for the 31 meter band are spread out over a wider dial area than is the case for the other bands. Note in this band L3 acts as the antenna coil and is coupled to L2 which is a C band coil. Coils L5 and L13 are, of course, regular C band coils. Both switches S1 and S2 complete the input to the 6SK7 for this band. Note 5, 6, 11, and 12 of S2 and 1, 3, 6 and 7 of S1 are used for this purpose. In the mixer input 7, 8 and 9 of S3 and 6, 8, 9, 10, 11 and 12 of S4 are used. For the oscillator circuit 11 and 12 of S5 and 1, 7, 9 and 12 of S6 are used. For the shorting action for this band 2, 3, 4 and 5 of S3 short L6, L7 and C12, 4 and 5 of S5 and 3, 4, 5 and 6 of S6 short C33, L15 and C27.

Figure 33 shows the C band con-

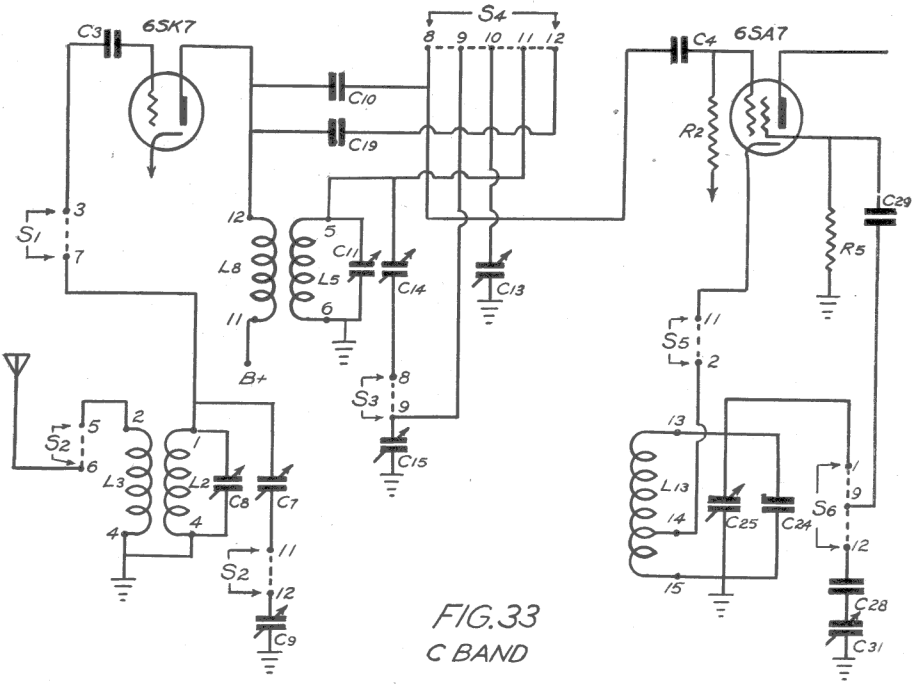
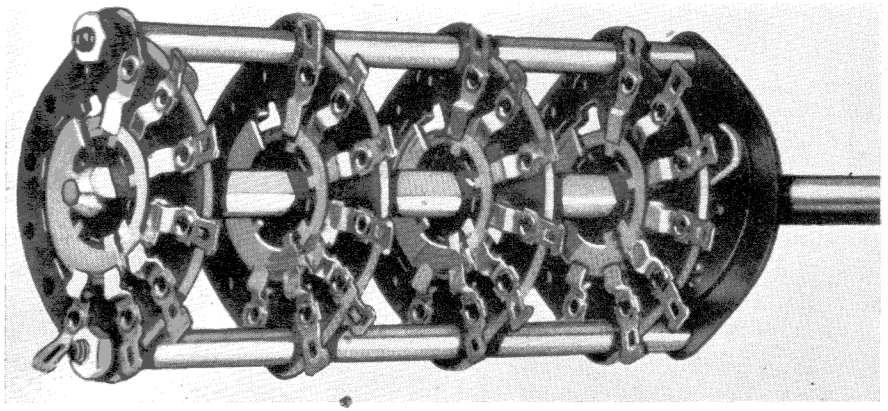


FIG. 33
C BAND

nections. For this band 5 and 6 of S2 complete the antenna circuit, 3 and 7 of S1 complete the 6SK7 input circuit, 8 and 9 of S3 and 8, 9, 10, 11 and 12 of S4 complete the mixer input circuit. For the oscillator circuit 2 and 11 of S5 and 1, 9 and 12 of S6 are used. For the shorting action 9, 10 and 11 of S1 short or ground the push-button and loop circuit leads to prevent these from absorbing energy from the tuned C band circuits; 2, 3, 4 and 5 of S3 short L7, C12, L6 and C17; 5 of S5 and 5, 6 and 7 of S6 short L15, C27, C34, C30 and C32.

From a study of the foregoing circuits you can see that multiband circuits are complex and difficult to trace. Fortunately, the switches rarely, if ever, need replacing and only occasionally will it be necessary to replace condensers and coils associated with them. This will never be a difficult job because only a few connections are involved. If you ever have to trace an entire multiband switching system make up a table of the switch terminals brought together by each position of the range switch. Then draw the circuits which your table indicates should be connected together. In this way you can make an accurate drawing of the circuits if you are careful to get the correct information in your table. If you should need to replace a multiband switch with a new one, you will have a minimum of trouble if you remove one wire at a time from the old switch and solder it to its corresponding position on the new switch. If one wire is disconnected and reconnected at a time there is a minimum chance for errors.



The above view shows the mechanical details of a four deck all wave switch. Note the various shapes of the rotating arms of each deck. This type of switch is rigidly constructed and will last for several years with normal use. Courtesy of P. R. Mallory Co.

HOW TO IDENTIFY VARIOUS STAGES OF A RADIO

In the complex radio set of today, it is sometimes difficult to identify the various stages of a radio, particularly from an above chassis view. Also many radio sets employ more than one tube of the same type. In others none of the tube sockets are marked or identified, and it sometimes becomes a problem to determine which tube is to fit into which socket. This problem becomes increasingly important in the modern radio where all of the sockets may be of the unmarked octal type. Sometimes the receiver owner may remove the tubes to have them tested or remove them for other reasons and then fail to get them replaced properly. This may or may not cause damage, depending on the tubes and circuits involved. At any rate, it is often necessary for the professional radio man to get the tubes replaced properly, and it is often necessary for him to identify a particular tube's function from the top side of the chassis without removing it from the cabinet.

One of the first things to look for in a case of this kind is the manufacturer's label. It may be placed on the receiver chassis, its cabinet, or, in the case of a small receiver, this label may be on the bottom of the cabinet. At any rate, look over the entire arrangement very carefully. The label may be in the form of a large sheet which will include a *tube layout* showing the tube positions and the location of trimmer condensers. In some cases the name plate is in one place and the tube layout in another. So before you do anything, look over the entire cabinet and chassis for a manufacturer's tube layout. It will quickly solve your problem if you can find it. One other possible source for this information is from the receiver owner. Often the manufacturer includes a booklet of instructions which includes a tube layout. Receiver owners sometimes forget they have such a book, and it is always well to ask if they have one. The remaining source for this information is the

manufacturer's original diagram of the receiver. The receiver owner is not likely to have this information, but you may have it in your collection of receiver diagrams, or such information can often be found in diagram manuals—a complete set of these is usually available for reference at any radio parts jobber's store.

There are many receivers in use for which there is no tube layout, or it may not be convenient to refer to other sources. In this case, the radioman must rely on his general knowledge and experience in identifying stages and tube types for certain tube sockets. There are a few general rules which, if kept in mind, will aid greatly in this work. One of the first things to be done is to identify the type of receiver—that is, whether it is battery, DC, AC, AC-DC or battery AC-DC operated.

Next you will want to know if the receiver is a super or a TRF. Clues which identify a TRF receiver are three and four gang tuning condensers, no IF transformers present, a one band receiver as indicated by the tuning dial, no selector switches for changing tuning bands, no converter tube such as the 6A7, 6A8, etc., will be used. The receiver will usually be large and of the older type—some few 4 tube TRF receivers are used, but you can easily determine if a TRF circuit is employed if you will check to see whether oscillator coils and IF transformers are present.

There are several things about a super that will enable you to identify it. Some of these are not present or evident in all super receivers, but enough of them will be evident to enable you to make the identification. Most supers employ a two-gang condenser, and, in many cases, the oscillator rotor tuning condenser plates will be smaller than those of the RF or of special shape. A converter or separate oscillator tube will be employed, IF transformers will be present, if more than two tuning bands are employed the receiver is sure to be a super. Little things like those just mentioned should help you to make proper identification.

The tube type in a given socket or in a tube layout is one of the most valuable means of identifying a stage—whether rectifier, output, detector, IF, oscillator or RF. If you will try to remember tube designations and what types are used for a specific function, it will aid greatly in identifying stages. Most receivers are of the super type and designed for AC operation. Thus it is known that they will employ a rectifier and converter or, perhaps, a separate oscillator. There are not so many rectifiers or converters that you cannot remember them, so in an AC super you will expect to find a rectifier such as the 5Y3, 35Z5, etc., a converter such as the 6K8, 6A8, 12SA7, etc. Then you should look for an output tube or tubes—the filament voltage of the other tubes in the receiver indicating the type of output tubes to expect. The converter tube will be located near the tuning condenser gang, the IF tubes near the IF transformers, the second detector near the output tubes, etc. Thus identifying stages, as you can see, is more or less a process of elimination. Once you identify two or

more stages you can almost guess what the rest of them should be in a given receiver.

Several volume control and tube manufacturers put out a guide which lists the tubes and many parts requirements of most radio sets. These are usually very low in price—from about 35 cents to $1.50 and are obtainable from most radio parts jobbers or direct from the manufacturers. One such book is available from the Sylvania Electric Products Company, Emporium, Penna. It is called a Tube Complement Book. It lists receiver model numbers, the number of all tubes, types required, the type of pilot light required and gives the IF frequency for most receivers. You will find such a book as this very valuable in your work.

These questions are designed to test your knowledge of this lesson. Read them over first to see if you can answer them. If you feel confident that you can, then write out your answers, numbering them to correspond to the questions. If you are not confident that you can answer the questions, re-study the lesson one or more times before writing out your answers. Be sure to answer every question, for if you fail to answer a question, it will reduce your grade on this lesson. When all questions have been answered, mail them to us for grading.

QUESTIONS

No. 1. What is a good frequency ratio of a tuning band in an all wave receiver?

No. 2. In which stages of a superheterodyne receiver do you expect to find the coils and switches for all wave reception?

No. 3. Why is it possible to have each tuned band of an all wave superheterodyne track with independent accuracy although the same gang condenser tunes all bands?

No. 4. Of the two bands used by the circuit of Fig. 13, are the switches shown connecting the circuit for the higher or lower frequency band, and which coil, in this case, acts as the antenna coil?

No. 5. Why is it in all wave receivers that certain coils and circuits not in use are shorted or grounded?

No. 6. What is the purpose of a shorting shoe in an all wave selector switch?

No. 7. Referring to Fig. 14, if the arm of switch deck G is turned to G2, what will be the positions of the arms of decks C, D and A?

No. 8. How many individually switched circuits are involved in Fig. 15 for each wave band including the shorting rings?

No. 9. In Fig. 17, if coils L10 and L13 are oscillator coils for one band, name the corresponding RF coils for the same band.

No. 10. In Fig. 20, name and describe the three switch arms for the switch S.